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(54) **Wireless communications systems employing free-space optical communications links**

Drahlose Übertragungssysteme mit im freien Raum optischen Übertragungsstrecken

Systèmes de communication sans fil avec des liaisons de communication optiques en air libre

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(56) References cited:
EP-A- 0 391 597
GB-A- 2 261 575
US-A- 5 493 436

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Description

Background of the Invention

[0001] This invention relates to wireless communications systems such as cellular telephone systems, and more particularly to wireless communications systems with increased communication capacity.

[0002] Wireless communications systems such as cellular telephone systems rely on a relatively small number of radio frequencies that are broadcast from relatively low-power transceivers so that the signals travel only a relatively short distance from the transceiver (e.g., approximately to the boundary of a cell having a radius of one to three miles from the transceiver). The same radio frequencies can therefore be reused for other messages in nearby cells without unacceptable interference between the different messages on the same frequencies in different cells. However, because the number of radio frequencies allowed for this type of communication is limited by governmental regulation and other considerations, only a correspondingly limited number of cellular telephone calls can be supported in any given cell at any one time. In high usage areas this may prevent some calls from being completed and/or may force some callers to wait for service. This is obviously undesirable.

[0003] One possible approach to increasing the number of calls that can be simultaneously supported in an area is to reduce the size of the cells. This allows greater reuse of the available radio frequencies. For example, a conventional cell may be subdivided into a plurality of subcells, each having a transceiver of even lower power than the conventional transceiver associated with a conventional cell. If a conventional cell is subdivided into four subcells, it is theoretically possible to support four times as many calls in the area of the original cell as could be supported if the cell were not subdivided.

[0004] A possible disincentive to subdividing cells is the expense of running high-grade, hard-wired communications links such as optical fiber to all the new subcell transceiver locations.

[0005] In view of the foregoing, it is an object of this invention to reduce the cost and difficulty of increasing the capacity of wireless communications systems.

[0006] It is a more particular object of the invention to provide wireless communications systems with subcells that do not have hard-wired connections to all the subcell transceiver locations.

[0007] US patent No. 5 493 436 discloses a wireless communications apparatus according to the preamble of claim 1.

[0008] The apparatus of US patent No. 5 493 436 has a private branch exchange system (PBX) with a central transceiver that is contained within the same building as the PBX. An optical antenna may within the same building as the PBX may be aimed at a temporary site, such as a work site or a recreation site, to provide temporary communication to that site.

[0009] EP-A-0 391 597 discloses a communications system in which transducers are connected with a base station by a network of optical fibres. The base station is also connected with micro-cells, again by optical fibres.

[0010] These and other objects of the invention are accomplished in accordance with the principles of the invention by using point-to-point, substantially unguided, free-space, optical communication between a central location in a wireless communications system cell and each of a plurality of subcell transceivers in that cell. For example, the central location may be the location of the pre-existing radio frequency transceiver of the cell. This transceiver is converted to a plurality of central optical transceivers. Each of the subcells is provided with an optical transceiver that is centrally located within the associated subcell and therefore remote from the previously mentioned central optical transceivers. Each subcell optical transceiver is optically coupled to a respective one of the central optical transceivers by a substantially unguided, free-space, optical communications link (e.g., bi-directional, line-of-sight, infrared transmission). Each subcell also includes a radio frequency transceiver for serving wireless communications units (e.g., mobile or cellular telephones) in that subcell. And each subcell includes circuitry for interfacing between its optical and radio frequency transceivers. The central optical transceivers typically communicate with portions of the overall system beyond the cell via a hard-wired communications link (e.g., a bi-directional fiber optic link to a mobile telephone switching office).

[0011] The use of substantially unguided, free-space, optical communications between the central optical transceivers and the subcell transceivers avoids the need for additional, hard-wired connections to new subcell transceiver locations. This reduces the cost of providing smaller wireless communications cells and therefore wireless communications systems with greater capacity through the greater reuse of a limited number of radio frequencies.

[0012] Further features of the invention, its nature and various advantages, will be more apparent from the accompanying drawings and the following detailed description of the preferred embodiments.

Brief Description of the Drawings

[0013] FIG. 1 is a simplified schematic diagram of a representative portion of an illustrative embodiment of a wireless communications system constructed in accordance with this invention.

[0014] FIG. 2 is a simplified schematic diagram of an illustrative embodiment of a portion of the apparatus shown in FIG. 1.

[0015] FIG. 3 is a more detailed, but still simplified schematic block diagram of an illustrative embodiment

of another portion of the apparatus shown in FIG. 1.

Detailed Description of the Preferred Embodiments

[0016] In FIG. 1 chain-dotted line 20 represents the approximate boundary of a conventional cell in wireless communications system 10. For example, cell 20 may be approximately circular with a radius in the range from about 1.6 to 4.8 km (about one to three miles) from a central antenna 30. In accordance with the present invention, cell 20 is subdivided into a plurality of subcells 40a-d. Each of subcells 40a-d is served by a respective antenna 50a-d. The apparatus at antenna 30 communicates with switching equipment 70 (e.g., a mobile telephone switching office) via hard-wired communications link 60. Link 60 is preferably optical fiber, but it can alternatively be an electronic link. Cell 20 is only representative of several similar cells that may be similarly served by switching office 70. Switching office 70 is connected to conventional telephone company switching equipment 90 via communications link 80 for communication with the global communications network generally. If desired, components 70 and 90 may be at the same physical location.

[0017] Although it is generally assumed in this discussion that communications system 10 is a cellular telephone system, it will be understood that the invention is equally applicable to any type of wireless communications system (e.g., paging systems, cellular telephone systems with enhanced features, and the like).

[0018] The apparatus at antenna 30 communicates with the apparatus at each of antennas 50a-d via substantially unguided optical communication between the antennas. In particular, antenna 30 has light sources for sending light 32a-d through the atmosphere to each of antennas 50a-d. Each antenna 50a-d receives the light thus transmitted to it from antenna 30 and broadcasts radio frequency signals within the associated subcell 40a-d corresponding to the information received optically (or an appropriate part of that information). Cellular telephones that are in use within a subcell 40a-d receive this radio frequency information and use other, dynamically assigned radio frequencies to send other information back to the associated antenna 50a-d. The apparatus at each subcell antenna 50a-d uses a modulated light source which is part of that apparatus to send that information from the antenna 50a-d back to antenna 30 via substantially unguided light 52a-d. The apparatus associated with antenna 30 places the information thus received from antennas 50a-d on communications link 60 for transmission to switching office 70 and, if necessary, on to switch 90. Infrared light is preferably used for optical links 32a-d and 52a-d.

[0019] The use of substantially unguided, free-space, optical links 32a-d and 52a-d between antenna 30, on the one hand, and antennas 50a-d, on the other hand, facilitates subdividing cell 20 into subcells 40a-40d without the expense of having to provide hard-wired connections like link 60 from switching office 70 to all of antennas 50a-d. For example, a pre-existing link 60 between switching office 70 and a formerly radiofrequency transceiver 30 can be reused in this system. Transceiver 30 is converted from a radio frequency transceiver to a plurality of optical transceivers for optical communication with transceivers 50a-d. No additional hard-wired connections are needed between switching office 70 and transceivers 50a-d.

[0020] An illustrative embodiment of the optical portion of representative subcell apparatus 50 in accordance with this invention is shown in FIG. 2. Consideration will first be given to the processing of incoming light 32 from antenna 30. It is assumed that incoming light 32 includes five different wavelength-division-multiplexed light wavelengths. Four of these wavelengths are respectively the message information signals for the four subcells 40a-d served by antenna 30. The fifth wavelength is a control information signal shared by all of the subcells 40a-d served by antenna 30. For example, this control information may determine the radio frequencies used by the apparatus at each of remote antennas 50a-d for communication with the cellular telephones being served from that remote antenna.

[0021] Collimating lens 110 focuses incoming light 32 into optical fiber 120 leading to port 2 of forward propagating optical circulator 130. As is conventional for such devices, forward propagating optical circulator 130 propagates optical information from port 1 to port 2, and from port 2 to port 3, but not from port 3 to port 1. (This characteristic is extendable to any number of ports.) Thus in FIG. 2 optical circulator 130 applies the incoming light from port 2 to the optical fiber 140 connected to its port 3.

[0022] Optical fiber 140 contains Bragg grating filters 150a-c for blocking the further propagation of the three message information signal wavelengths that are not used by the representative subcell apparatus being discussed. These three wavelengths are the message information signal wavelengths used respectively by the three other subcells 40 within cell 20. Each Bragg grating 150 is a wavelength selective mirror formed into fiber 140 with a reflectivity approaching 100% at the wavelength blocked by that grating. The cumulative effect of Bragg gratings 150a-c is therefore to allow only the message information signal wavelength to be used by subcell apparatus 50 and the control signal wavelength to be applied to port 1 of forward propagating optical circulator 160. (Note that circulator 130 blocks the light reflected by Bragg gratings 150. This is so because circulator 130 does not propagate either from port 3 to port 2 or from port 3 to port 1.)

[0023] Circulator 160 applies the light it receives via port 1 to the optical fiber 170 which is connected to its port 2. Optical fiber 170 includes Bragg grating filter 180 for blocking further propagation along that fiber of the control signal wavelength. Thus only the message information signal wavelength to be used by subcell appa-

ratus 50 passes through Bragg grating 180 and is optically coupled to photodetector 190. Photodetector 190 is the message information signal input to the electronic circuitry 200 of subcell apparatus 50.

[0024] Bragg grating 180 reflects the control signal wavelength back to port 2 of optical circulator 160. Accordingly, circulator 160 applies the control signal wavelength from port 2 to the optical fiber 210 connected to its port 3. Optical fiber 210 is optically coupled to photodetector 220, which is the control signal input to electronic circuitry 200.

[0025] Electronic circuitry 200 uses the control and message information signals it receives from elements 190 and 220 to produce and broadcast the radio signal frequencies that it needs to send to the cellular telephones in the associated subcell 40. Electronic circuitry 200 also receives and processes the signals transmitted back by those cellular telephones. The radio frequency aspects of the operation of subcell apparatus 50 may be substantially conventional (except that the broadcast power and reception sensitivity of the apparatus may be reduced to be commensurate with the relatively small geographical area of a subcell 40 as compared to a conventional cell 20).

[0026] Radio frequency signals received by subcell apparatus 50 from cellular telephones in the associated subcell are processed by the electronic circuitry in the substantially conventional way and applied as a modulating signal to light source 230. Light from light source 230 is optically coupled to optical fiber 240, which is connected to port 1 of optical circulator 130. Accordingly, light from port 1 of circulator 130 is applied to optical fiber 120 and passed out through collimating lens 110 for transmission back to transceiver 30 as substantially unguided light 52.

[0027] The wavelength of light source 230 is preferably different from any of incoming wavelengths 32. Each of the subcells 40 in a cell 20 also preferably has its own unique light source 230 wavelength.

[0028] FIG. 3 shows an illustrative embodiment of elements 30, 60, and 70 in more detail. At central antenna 30 a plurality of free-space optical transceivers 330a-d are respectively aimed at subcell antennas 50a-d. Each of transceivers 330a-d transmits the light it receives from mobile telephone switching office 70 via optical fiber 60 to the associated subcell antenna 50a-d. As described earlier, this transmission from antenna 30 to antennas 50a-d is free-space optical transmission 32a-d. All of transceivers 330a-d may transmit substantially the same information. This information includes a separate message information wavelength for each of subcells 40a-d, and a further separate control information wavelength carrying information for controlling all of subcells 40a-d. Each subcell apparatus filters out the message information wavelength intended for it, as well as the control information wavelength, as described above in connection with FIG. 2.

[0029] Each of transceivers 330a-d also receives the light 52a-d transmitted back to central antenna 30 from the associated subcell antenna 50a-d. As noted earlier in connection with FIG. 2, each of subcells 50a-d preferably transmits back to antenna 30 via a unique light wavelength.

[0030] Coupler 320 distributes the light coming in from optical fiber 60 to the optical fibers 322a-d leading to transceivers 330a-d. In the opposite direction, coupler 320 combines the light received back from subcell antennas 50a-b for application to optical fiber 60. Optical fiber 60 may include a conventional erbium doped fiber amplifier 310 for optically amplifying the light passing in either or both directions along the optical fiber.

[0031] At mobile telephone switching office 70 forward propagating optical circulator 350 directs light coming in from optical fiber 60 via port 2 to demultiplexer 360 via another optical fiber connected to port 3. Demultiplexer 360 separates the multiple light wavelengths it receives from port 3 of the optical circulator into separate optical signals 362a-d. Each of these optical signals is applied to an optical detector in order to produce an electronic signal applied to conventional call processing circuitry 370.

[0032] Call processing circuitry 370 also produces electronic signals for transmission to each of subcells 40a-d. Each of these electronic signals is converted to a respective optical signal 372a-e having a separate wavelength. Signals 372a-d are respectively the message information signals for subcells 40a-d, while signal 372e is the control information signal for all of subcells 40a-d. Coupler 380 combines these five optical signals into a wavelength division multiplexed optical signal which is applied to port 1 of optical circulator 350. Circulator 350 transmits this signal from port 1 to port 2, where it is applied to optical fiber 60 for transmission to central antenna 30.

[0033] It will be noted that in the depicted preferred embodiment an existing fiber optic link 60 is used between mobile telephone switching office 70 and central antenna 30 so that optical signals can pass substantially directly between optical fiber 60, on the one hand, and free-space links 32a-d and 52a-d, on the other hand. No electronic circuitry is needed to interface between these optical fiber and free-space links. This facilitates the provision of high-speed and error-free communication between mobile telephone switching office 70 and subcells 40a-d.

[0034] It will be understood that the foregoing is only illustrative of the principles of this invention, and that various modifications can be made by those skilled in the art without departing from the scope of the appended claims. For example, subdividing cell 20 into four subcells 40a-d is only illustrative, and a cell can be subdivided into any number of subcells. As another example of modifications within the scope of the invention, the various components shown in the drawings are presently preferred, but various aspects of the invention can be implemented using other components if desired. The

optical communication described herein can be by either digital or analog modulation of the light being transmitted. As a possible alternative to using multiple light wavelengths to respectively transmit information to the multiple subcells, the information for all subcells could be transmitted on one wavelength, with each subcell including apparatus for electronically extracting the information intended for that subcell. This would somewhat simplify the optical processing apparatus for light being transmitted to and processed by the subcells, but it would increase the complexity of the electronic circuitry 200 required at each subcell.

Claims

1. A wireless communications apparatus comprising:

   a plurality of central optical transceivers (30) associated with a cell (20);
   a plurality of remote optical transceivers (50a-50d), each of said remote optical transceivers (50a-50d) being adapted to communicate with a respective one of said central optical transceivers (30) via substantially unguided light (52a-52d) passing between said remote optical transceiver (50a-50d) and the associated central optical transceiver (30); and
   electronic circuitry associated with each of said remote optical transceivers (50a-50d) for converting between radio frequency signals in the associated subcell (40a-40d) and light communicated by said remote optical transceiver;
   the apparatus being characterised in that it further comprises:

      wireless communications control circuitry (70) remote from said central and remote optical transceivers (30, 50a-50d); and
      a communications link (60) between said wireless communications control circuitry (70) and said central optical transceivers (30);
      in that each of the remote optical transceivers is associated with a respective one of a plurality of sub-cells (40a-40d) within said cell;
      and in that the communication link comprises optical fibre between said wireless communications control circuitry (70) and said central optical transceivers (30).

2. An apparatus as claimed in claim 1 wherein light having a unique wavelength is used for communicating information associated with each of said subcells.

3. An apparatus as claimed in claim 1 wherein light having a first unique wavelength is used for communicating information to each subcell and wherein light having a second unique wavelength is used for communicating information from each subcell.

4. An apparatus as claimed in claim 3 wherein each of said central optical transceivers transmits, in use, to the associated remote optical transceiver light which includes said wavelengths used for communication to all of said subcells.

5. An apparatus as claimed in claim 4 wherein each of said remote optical transceivers includes optical filter apparatus for selecting from the wavelengths received by said transceiver the wavelength used for communication to the associated subcell.

6. An apparatus as claimed in claim 5 wherein said optical filter apparatus comprises Bragg grating apparatus.

7. An apparatus as claimed in claim 3 wherein light having a further unique wavelength is used for communicating control information to all of said subcells.

8. An apparatus as claimed in claim 7 wherein each of said central optical transceivers transmits, in use, to the associated remote optical transceiver light which includes said wavelengths used for communicating said information and said control information to all of said subcells.

9. An apparatus as claimed in claim 8 wherein each of said remote optical transceivers includes optical filter apparatus for selecting from the wavelengths received by said transceiver the wavelength used for communicating said information to the associated subcell and the wavelength used for communicating said control information to all of said subcells.

10. An apparatus as claimed in claim 9 wherein said filter apparatus comprises Bragg grating apparatus.

11. An apparatus as claimed in claim 1 wherein said optical fibre transmits, in use, light from said wireless communications control circuitry to said central optical transceivers, each of which passes a portion of said light on to the associated remote optical transceiver.

12. An apparatus as claimed in claim 11 wherein said optical fibre includes erbium doped fibre amplifier apparatus for optically amplifying light being transmitted via said optical fibre.

13. An apparatus as claimed in claim 1 wherein said optical fibre transmits, in use, to said wireless com-

munications control circuitry light received by each of said central optical transceivers from the associated remote optical transceiver.

14. An apparatus as claimed in claim 13 wherein each of said remote optical transceivers transmits, in use, light of a unique wavelength to the associated central optical transceiver, and wherein said apparatus further comprises optical coupler apparatus for combining, for application to said optical fibre, the light received by all of said central optical transceivers from said remote optical transceivers.

15. An apparatus as claimed in claim 13 wherein said optical fibre includes erbium doped fibre amplifier apparatus for optically amplifying light being transmitted via said optical fibre from said central optical transducers to said wireless communications control circuitry.

16. A wireless communication method comprising the steps of:

(a) communicating information between wireless communications control circuitry (70) and a central location (30);
(b) communicating at least some of said information between said central location (30) and each of a plurality of remote locations (50a-50d) via substantially unguided light (32a-32d) passing between said central location (30) and each of said remote locations (50a-50d); and
(c) communicating at least some of said information between each of said remote locations (50a-50d) and wireless communication devices in the vicinity of said remote location via radio signals (52a-52d) broadcast between said remote location (50a-50d) and said wireless communication devices;

wherein said communicating between said wireless communications control circuitry (70) and said central location is via optical communication; the method being characterised in that the wireless communication control circuitry (70) is remote from the central location (30).

17. A method as claimed in claim 16 wherein said optical communication is guided via optical fibre between said wireless communications circuitry (70) and said central location.

18. A method as claimed in claim 16 wherein said communicating between said wireless communications control circuitry (70) and said central location is bidirectional.

19. A method as claimed in claim 16 wherein said communicating between said central location and each of said remote locations is bi-directional.

20. A method as claimed in claim 16 wherein said communicating between said remote locations and said wireless communication devices is bi-directional.

21. A method as claimed in claim 16 wherein said information includes message information and control information.

22. A method as claimed in claim 21 wherein said control information includes radio frequency assignment information for controlling selection of radio frequencies to be used for said communicating between said remote locations and said wireless communication devices.

23. A method as claimed in claim 16 wherein said communicating between said wireless communications control circuitry (70) and said central location is bidirectional, and wherein light of different wavelengths is used for communicating in each direction.

24. A method as claimed in claim 18 wherein light of different wavelengths is used for communicating in each direction.

25. A method as claimed in claim 23 wherein said information includes message information and control information, and wherein light of different wavelengths is used for communicating said message information and said control information from said wireless communications control circuitry (70) to said central location.

26. A method as claimed in claim 24 wherein said information includes message information and control information, and wherein light of different wavelengths is used for communicating said message information and said control information from said central location to said remote locations.

27. A method as claimed in claim 25 wherein said message information includes a plurality of message portions, each of which is for use at a respective one of said remote locations, and wherein light of a different wavelength is used for communicating each of said message portions from said wireless communications control circuitry (70) to said central location.

28. A method as claimed in claim 26 wherein said message information includes a plurality of message portions, each of which is for use at a respective one of said remote locations, and wherein light of a different wavelength is used for communicating each of said message portions from said central lo-

cation to said remote locations.

29. A method as claimed in claim 28 wherein said central location communicates all of said message portions to all of said remote locations.

30. A method as claimed in claim 29 further comprising:
filtering at each of said remote locations to select the wavelength used for the message portion for use at that remote location and to reject the wavelengths used for the message portions for use at others of said remote locations.

31. A method as claimed in claim 19 wherein light of a different wavelength is used for communicating from each of said remote locations to said central location.

32. An apparatus as claimed in claim 1 wherein the receiver (30) transfers, in use, said radio frequency signals (52a-d) on said communications link (60) to said wireless communications control circuitry (70) being a mobile telephone switching office.

33. A method as claimed in claim 16 wherein said receiver (30) transfers said radio frequency signals (52a-d) on said communications link (60) to said wireless communications control circuitry (70) being a mobile telephone switching office.

Patentansprüche

1. Drahtlose Kommunikationsvorrichtung mit:

einer Vielzahl von zentralen optischen Sendeempfängern (30), die einer Zelle (20) zugeordnet sind;

einer Vielzahl von entfernten optischen Sendeempfängern (50a-50d), wobei jeder der entfernten optischen Sendeempfänger (50a-50d) ausgelegt ist, mit einem jeweiligen der zentralen optischen Sendeempfänger (30) über im wesentlichen ungeführtes Licht (52a-52d) zu kommunizieren, das zwischen dem entfernten optischen Sendeempfänger (50a-50d) und dem zugeordneten zentralen optischen Sendeempfänger (30) läuft; und

einem elektronischen Schaltkreis, der jedem der entfernten optischen Sendeempfänger (50a-50d) zugeordnet ist, zum Konvertieren zwischen Radiofrequenzsignalen in der zugeordneten Unterzelle (40a-40d) und Licht, das von dem entfernten optischen Sendeempfänger kommuniziert wird;

wobei die Vorrichtung gekennzeichnet ist dadurch, daß sie weiter umfaßt:

einen drahtlosen Kommunikationssteuerschaltkreis (70) entfernt von den zentralen und entfernten optischen Sendeempfängern (30, 50a-50d); und

eine Kommunikationsverbindung (60) zwischen dem drahtlosen Kommunikationssteuerschaltkreis (70) und den zentralen optischen Sendeempfängern (30);

dadurch, daß jeder der entfernten optischen Sendeempfänger einer jeweiligen einer Vielzahl von Unterzellen (40a-40d) innerhalb der Zelle zugeordnet ist;

und dadurch, daß die Kommunikationsverbindung eine optische Faser zwischen dem drahtlosen Kommunikationssteuerschaltkreis (70) und den zentralen optischen Sendeempfängern (30) umfaßt.

2. Vorrichtung nach Anspruch 1, wobei Licht mit einer einzigartigen Wellenlänge verwendet wird, zum Kommunizieren von Information die jeder der Unterzellen zugeordnet ist.

3. Vorrichtung nach Anspruch 1, wobei Licht mit einer ersten einzigartigen Wellenlänge zum Kommunizieren von Information zu jeder Unterzelle verwendet wird, und wobei Licht mit einer zweiten einzigartigen Wellenlänge zum Kommunizieren von Information von jeder Unterzelle verwendet wird.

4. Vorrichtung nach Anspruch 3, wobei jeder der zentralen optischen Sendeempfänger bei einer Verwendung Licht zu dem zugeordneten entfernten optischen Sendeempfänger überträgt, das auch Wellenlängen einschließt, die für eine Kommunikation zu sämtlichen der Unterzellen verwendet werden.

5. Vorrichtung nach Anspruch 4, wobei jeder der entfernten optischen Sendeempfänger eine optische Filtervorrichtung einschließt, um aus den durch den Sendeempfänger empfangenen Wellenlängen die Wellenlänge auszuwählen, die für eine Kommunikation zu der zugeordneten Unterzelle verwendet wird.

6. Vorrichtung nach Anspruch 5, wobei die optische Filtervorrichtung eine Bragg-Gittervorrichtung umfaßt.

7. Vorrichtung nach Anspruch 3, wobei Licht mit einer weiteren einzigartigen Wellenlänge zum Kommunizieren von Steuerinformation zu sämtlichen der Un-

terzellen verwendet wird.

8. Vorrichtung nach Anspruch 7, wobei jeder der zentralen optischen Sendeempfänger bei einer Verwendung Licht zu dem zugeordneten entfernten optischen Sendeempfänger überträgt, das die Wellenlängen einschließt, die für ein Kommunizieren der Information und der Steuerinformation zu sämtlichen der Unterzellen verwendet wird.

9. Vorrichtung nach Anspruch 8, wobei jeder der entfernten optischen Sendeempfänger eine optische Filtervorrichtung einschließt, um aus den durch den Sendeempfänger empfangenen Wellenlängen die Wellenlänge, die für ein Kommunizieren der Information zu der zugeordneten Unterzelle verwendet wird, und die Wellenlänge, die für ein Kommunizieren der Steuerinformation zu sämtlichen der Unterzellen verwendet wird, auszuwählen.

10. Vorrichtung nach Anspruch 9, wobei die Filtervorrichtung eine Bragg-Gittervorrichtung umfaßt.

11. Vorrichtung nach Anspruch 1, wobei die optische Faser bei einer Verwendung Licht von dem drahtlosen Kommunikationssteuerschaltkreis zu den zentralen optischen Sendeempfängern überträgt, wobei jeder von ihnen einen Teil des Lichtes zu dem zugeordneten entfernten optischen Sendeempfänger weitergibt.

12. Vorrichtung nach Anspruch 11, wobei die optische Faser eine Erbium-dotierte Faserverstärkervorrichtung einschließt, um Licht, das über die optische Faser übertragen wird, optisch zu verstärken.

13. Vorrichtung nach Anspruch 1, wobei die optische Faser bei einer Verwendung Licht, das durch jeden der zentralen optischen Sendeempfänger von dem zugeordneten entfernten optischen Sendeempfänger empfangen wird, zu dem drahtlosen Kommunikationssteuerschaltkreis überträgt.

14. Vorrichtung nach Anspruch 13, wobei jeder der entfernten optischen Sendeempfänger bei einer Verwendung Licht einer einzigartigen Wellenlänge zu dem zugeordneten zentralen optischen Sendeempfänger überträgt, und wobei die Vorrichtung weiter eine optische Kopplervorrichtung umfaßt, um das Licht, das durch sämtliche der zentralen optischen Sendeempfänger von den entfernten optischen Sendeempfängern empfangen wird, zum Anlegen an die optische Faser zu kombinieren.

15. Vorrichtung nach Anspruch 13, wobei die optische Faser eine Erbium-dotierte Faserverstärkervorrichtung einschließt, um Licht, das über die optische Faser von den zentralen optischen Sendeempfängern zu dem drahtlosen Kommunikationssteuerschaltkreis übertragen wird, optisch zu verstärken.

16. Drahtloses Kommunikationsverfahren mit den Schritten:

(a) Kommunizieren einer Information zwischen einem drahtlosen Kommunikationssteuerschaltkreis (70) und einem zentralen Ort (30);

(b) Kommunizieren von zumindest etwas der Information zwischen dem zentralen Ort (30) und jedem einer Vielzahl von entfernten Orten (50a-50d) über im wesentlichen ungeführtes Licht (32a-32d), das zwischen dem zentralen Ort (30) und jedem der entfernten Orte (50a-50d) läuft; und

(c) Kommunizieren von zumindest etwas der Information zwischen jedem der entfernten Orte (50a-50d) und drahtlosen Kommunikationseinrichtungen in der Nähe des entfernten Ortes über Radiosignale (52a-52d), die zwischen dem entfernten Ort (50a-50d) und den drahtlosen Kommunikationseinrichtungen gesendet werden; wobei das Kommunizieren zwischen dem drahtlosen Kommunikationssteuerschaltkreis (70) und dem zentralen Ort über eine optische Kommunikation geschieht; wobei das Verfahren dadurch gekennzeichnet ist, daß der drahtlose Kommunikationssteuerschaltkreis (70) entfernt von dem zentralen Ort (30) ist.

17. Verfahren nach Anspruch 16, wobei die optische Kommunikation über eine optische Faser zwischen dem drahtlosen Kommunikationsschaltkreis (70) und dem zentralen Ort geführt wird.

18. Verfahren nach Anspruch 16, wobei das Kommunizieren zwischen dem drahtlosen Kommunikationssteuerschaltkreis (70) und dem zentralen Ort bidirektional ist.

19. Verfahren nach Anspruch 16, wobei das Kommunizieren zwischen dem zentralen Ort und jedem der entfernten Orte bidirektional ist.

20. Verfahren nach Anspruch 16, wobei das Kommunizieren zwischen den entfernten Orten und den drahtlosen Kommunikationseinrichtungen bidirektional ist.

21. Verfahren nach Anspruch 16, wobei die Information eine Nachrichteninformation und eine Steuerinformation einschließt.

22. Verfahren nach Anspruch 21, wobei die Steuerinformation Radiofrequenz-Zuweisungsinformation

zum Steuern einer Auswahl von Radiofrequenzen einschließt, die für das Kommunizieren zwischen den entfernten Orten und den drahtlosen Kommunikationseinrichtungen zu verwenden sind.

23. Verfahren nach Anspruch 16, wobei das Kommunizieren zwischen dem drahtlosen Kommunikationssteuerschaltkreis (70) und dem zentralen Ort bidirektional ist, und wobei Licht unterschiedlicher Wellenlängen für ein Kommunizieren in jeder Richtung verwendet wird.

24. Verfahren nach Anspruch 18, wobei Licht unterschiedlicher Wellenlänge für ein Kommunizieren in jeder Richtung verwendet wird.

25. Verfahren nach Anspruch 23, wobei die Information eine Nachrichteninformation und eine Steuerinformation einschließt, und wobei Licht unterschiedlicher Wellenlängen für ein Kommunizieren der Nachrichteninformation und der Steuerinformation von dem drathlosen Kommunikationssteuerschaltkreis (70) zu dem zentralen Ort verwendet wird.

26. Verfahren nach Anspruch 24, wobei die Information eine Nachrichteninformation und eine Steuerinformation einschließt, und wobei Licht unterschiedlicher Wellenlängen für ein Kommunizieren der Nachrichteninformation und der Steuerinformation von dem zentralen Ort zu den entfernten Orten verwendet wird.

27. Verfahren nach Anspruch 25, wobei die Nachrichteninformation eine Vielzahl von Nachrichtenabschnitten einschließt, von welchen jeder für eine Verwendung bei einem jeweiligen der entfernten Orte ist, und wobei Licht einer unterschiedlichen Wellenlänge für ein Kommunizieren jedes der Nachrichtenabschnitte von dem drathlosen Kommunikationssteuerschaltkreis (70) zu dem zentralen Ort verwendet wird.

28. Verfahren nach Anspruch 26, wobei die Nachrichteninformation eine Vielzahl von Nachrichtenabschnitten einschließt, von welchen jeder für eine Verwendung in einem jeweiligen der entfernten Orte ist, und wobei Licht einer unterschiedlichen Wellenlänge für ein Kommunizieren jeder der Nachrichtenabschnitte von dem zentralen Ort zu den entfernten Orten verwendet wird.

29. Verfahren nach Anspruch 28, wobei der zentrale Ort sämtliche der Nachrichtenabschnitte zu den entfernten Orten kommuniziert.

30. Verfahren nach Anspruch 29, weiter umfassend:
ein Filtern bei jedem der entfernten Orte, um die Wellenlänge auszuwählen, die für den Nachrichtenabschnitt für eine Verwendung an dem entfernten Ort verwendet wird, und um die Wellenlängen, die für die Nachrichtenabschnitte für eine Verwendung an anderen der entfernten Orte verwendet werden, zurückzuweisen.

31. Verfahren nach Anspruch 19, wobei Licht einer unterschiedlichen Wellenlänge für ein Kommunizieren von jedem der entfernten Orte zu dem zentralen Ort verwendet wird.

32. Verfahren nach Anspruch 1, wobei der Empfänger (30) bei einer Verwendung die Radiofrequenzsignale (52a-d) auf der Kommunikationsverbindung (60) zu dem drahtlosen Kommunikationssteuerschaltkreis (70) überträgt, der ein mobiles Telefonvermittlungsbüro ist.

33. Verfahren nach Anspruch 16, wobei der Empfänger (30) die Radiofrequenzsignale (52a-d) auf der Kommunikationsverbindung (60) zu dem drahtlosen Kommunikationssteuerschaltkreis (70) überträgt, der ein mobiles Telefonvermittlungsbüro ist.

Revendications

1. Appareil de communication sans fil comprenant:

    une pluralité d'émetteurs-récepteurs optiques centraux (30) associés à une cellule (20);

    une pluralité d'émetteurs-récepteurs optiques à distance (50a-50d), chacun desdits émetteurs-récepteurs optiques à distance (50a-50d) étant adapté pour communiquer avec l'un respectif desdits émetteurs-récepteurs optiques centraux (30) via une lumière sensiblement non guidée (52a-52d) qui passe entre lesdits émetteurs-récepteurs optiques à distance (50a-50d) et l'émetteur-récepteur optique central associé (30); et

    un circuit électronique associé à chacun desdits émetteurs-récepteurs optiques à distance (50a-50d) pour réaliser une conversion entre des signaux haute fréquence dans la sous-cellule associée (40a-40d) et une lumière communiquée par ledit émetteur-récepteur optique à distance,

    l'appareil étant caractérisé en ce qu'il comprend en outre:

        un circuit de commande de communication sans fil (70) à distance desdits émetteurs-récepteurs optiques centraux et à distance (30, 50a-50d); et

une liaison de communication (60) entre ledit circuit de commande de communication sans fil (70) et lesdits émetteurs-récepteurs optiques centraux (30),

en ce que les émetteurs-récepteurs optiques à distance sont associés avec l'une respective d'une pluralité de sous-cellules (40a-40d) à l'intérieur de ladite cellule;

et en ce que la liaison de communication comprend une fibre optique entre ledit circuit de commande de communication sans fil (70) et lesdits émetteurs-récepteurs optiques centraux (30).

2. Appareil selon la revendication 1, dans lequel une lumière qui présente une unique longueur d'onde est utilisée pour communiquer une information associée à chacune desdites sous-cellules.

3. Appareil selon la revendication 1, dans lequel une lumière qui présente une première unique longueur d'onde est utilisée pour communiquer une information à chaque sous-cellule et dans lequel une lumière présentant une seconde unique longueur d'onde est utilisée pour communiquer une information depuis chaque sous-cellule.

4. Appareil selon la revendication 3, dans lequel chacun desdits émetteurs-récepteurs optiques centraux émet, en utilisation, sur l'émetteur-récepteur optique à distance associé une lumière qui inclut lesdites longueurs d'onde utilisées pour une communication sur toutes lesdites sous-cellules.

5. Appareil selon la revendication 4, dans lequel chacun desdits émetteurs-récepteurs optiques à distance inclut un appareil de filtre optique pour sélectionner parmi les longueurs d'onde qui sont reçues par ledit émetteur-récepteur la longueur d'onde qui est utilisée pour une communication sur la sous-cellule associée.

6. Appareil selon la revendication 5, dans lequel ledit appareil de filtre optique comprend un appareil de réseau de Bragg.

7. Appareil selon la revendication 3, dans lequel une lumière qui présente une autre unique longueur d'onde est utilisée pour communiquer une information de commande à toutes lesdites sous-cellules.

8. Appareil selon la revendication 7, dans lequel chacun desdits émetteurs-récepteurs optiques centraux émet, en utilisation, sur l'émetteur-récepteur optique à distance associé une lumière qui inclut lesdites longueurs d'onde qui sont utilisées pour communiquer ladite information et ladite information de commande à toutes lesdites sous-cellules.

9. Appareil selon la revendication 8, dans lequel chacun desdits émetteurs-récepteurs optiques à distance inclut un appareil de filtre optique pour sélectionner parmi les longueurs d'onde qui sont reçues par ledit émetteur-récepteur la longueur d'onde qui est utilisée pour communiquer ladite information à la sous-cellule associée et la longueur d'onde qui est utilisée pour communiquer ladite information de commande à toutes lesdites sous-cellules.

10. Appareil selon la revendication 9, dans lequel ledit appareil de filtre optique comprend un appareil de réseau de Bragg.

11. Appareil selon la revendication 1, dans lequel ladite fibre optique transmet, en utilisation, une lumière depuis ledit circuit de commande de communication sans fil jusqu'aux dits émetteurs-récepteurs optiques centraux dont chacun laisse passer une partie de ladite lumière jusque sur l'émetteur-récepteur optique à distance associé.

12. Appareil selon la revendication 11, dans lequel ladite fibre optique inclut un appareil d'amplificateur à fibre dopée à l'erbium pour amplifier optiquement une lumière qui est transmise via ladite fibre optique.

13. Appareil selon la revendication 1, dans lequel ladite fibre optique transmet, en utilisation, audit circuit de commande de communication sans fil une lumière qui est reçue par chacun desdits émetteurs-récepteurs optiques centraux depuis l'émetteur-récepteur optique à distance associé.

14. Appareil selon la revendication 13, dans lequel chacun desdits émetteurs-récepteurs optiques à distance transmet, en utilisation, une lumière d'une unique longueur d'onde à l'émetteur-récepteur optique central associé et dans lequel ledit appareil comprend en outre un appareil de coupleur optique pour combiner, pour une application sur ladite fibre optique, la lumière qui est reçue par tous lesdits émetteurs-récepteurs optiques centraux depuis lesdits émetteurs-récepteurs optiques à distance.

15. Appareil selon la revendication 13, dans lequel ladite fibre optique inclut un appareil d'amplificateur à fibre dopée à l'erbium pour amplifier optiquement une lumière qui est transmise via ladite fibre optique depuis lesdits émetteurs-récepteurs optiques centraux jusqu'audit circuit de commande de communication sans fil.

16. Procédé de communication sans fil comprenant les

étapes de:

a) communication d'une information entre un circuit de commande de communication sans fil (70) et un emplacement central (30);

b) communication d'au moins une certaine part de ladite information entre ledit emplacement central (30) et chacun d'une pluralité d'emplacements à distance (50a-50d) via une lumière sensiblement non guidée (32a-32d) qui passe entre ledit emplacement central (30) et chacun desdits emplacements à distance (50a-50d) ; et

c) communication d'au moins une certaine part de ladite information entre chacun desdits emplacements à distance (50a-50d) et des dispositifs de communication sans fil au voisinage dudit emplacement à distance via des signaux radio (52a-52d) qui sont diffusés entre ledit emplacement à distance (50a-50d) et lesdits dispositifs de communication sans fil,

dans lequel ladite communication entre ledit circuit de commande de communication sans fil (70) et ledit emplacement central est via une communication optique, le procédé étant caractérisé en ce que le circuit de commande de communication sans fil (70) est à distance de l'emplacement central (30).

17. Procédé selon la revendication 16, dans lequel ladite communication optique est guidée via une fibre optique entre ledit circuit de commande de communication sans fil (70) et ledit emplacement central.

18. Procédé selon la revendication 16, dans lequel ladite communication entre ledit circuit de commande de communication sans fil (70) et ledit emplacement central est bidirectionnelle.

19. Procédé selon la revendication 16, dans lequel ladite communication entre ledit emplacement central et chacun desdits emplacements à distance est bidirectionnelle.

20. Procédé selon la revendication 16, dans lequel ladite communication entre lesdits emplacements à distance et lesdits dispositifs de communication sans fil est bidirectionnelle.

21. Procédé selon la revendication 16, dans lequel ladite information inclut une information de message et une information de commande.

22. Procédé selon la revendication 21, dans lequel ladite information de commande inclut une information d'assignation de fréquence radio pour commander la sélection de fréquences radio destinées à être utilisées pour la communication entre lesdits emplacements à distance et lesdits dispositifs de communication sans fil.

23. Procédé selon la revendication 16, dans lequel ladite communication entre ledit circuit de commande de communication sans fil (70) et ledit emplacement central est bidirectionnelle et dans lequel une lumière de différentes longueurs d'onde est utilisée pour communiquer dans chaque sens.

24. Procédé selon la revendication 18, dans lequel une lumière de différentes longueurs d'onde est utilisée pour communiquer dans chaque sens.

25. Procédé selon la revendication 23, dans lequel ladite information inclut une information de message et une information de commande et dans lequel une lumière de différentes longueurs d'onde est utilisée pour communiquer ladite information de message et ladite information de commande depuis ledit circuit de commande de communication sans fil (70) jusqu'audit emplacement central.

26. Procédé selon la revendication 24, dans lequel ladite information inclut une information de message et une information de commande et dans lequel une lumière de différentes longueurs d'onde est utilisée pour communiquer ladite information de message et ladite information de commande depuis ledit emplacement central jusqu'auxdits emplacements à distance.

27. Procédé selon la revendication 25, dans lequel ladite information de message inclut une pluralité de parties de message dont chacune est pour une utilisation au niveau de l'un respectif desdits emplacements à distance et dans lequel une lumière d'une longueur d'onde différente est utilisée pour communiquer chacune desdites parties de message depuis ledit circuit de commande de communication sans fil (70) jusqu'audit emplacement central.

28. Procédé selon la revendication 26, dans lequel ladite information de message inclut une pluralité de parties de message dont chacune est pour une utilisation au niveau de l'un respectif desdits emplacements à distance et dans lequel une lumière d'une longueur d'onde différente est utilisée pour communiquer chacune desdites parties de message depuis ledit emplacement central jusqu'auxdits emplacements à distance.

29. Procédé selon la revendication 28, dans lequel ledit emplacement central communique toutes lesdites

parties de message à tous lesdits emplacements à distance.

30. Procédé selon la revendication 29, comprenant en outre:

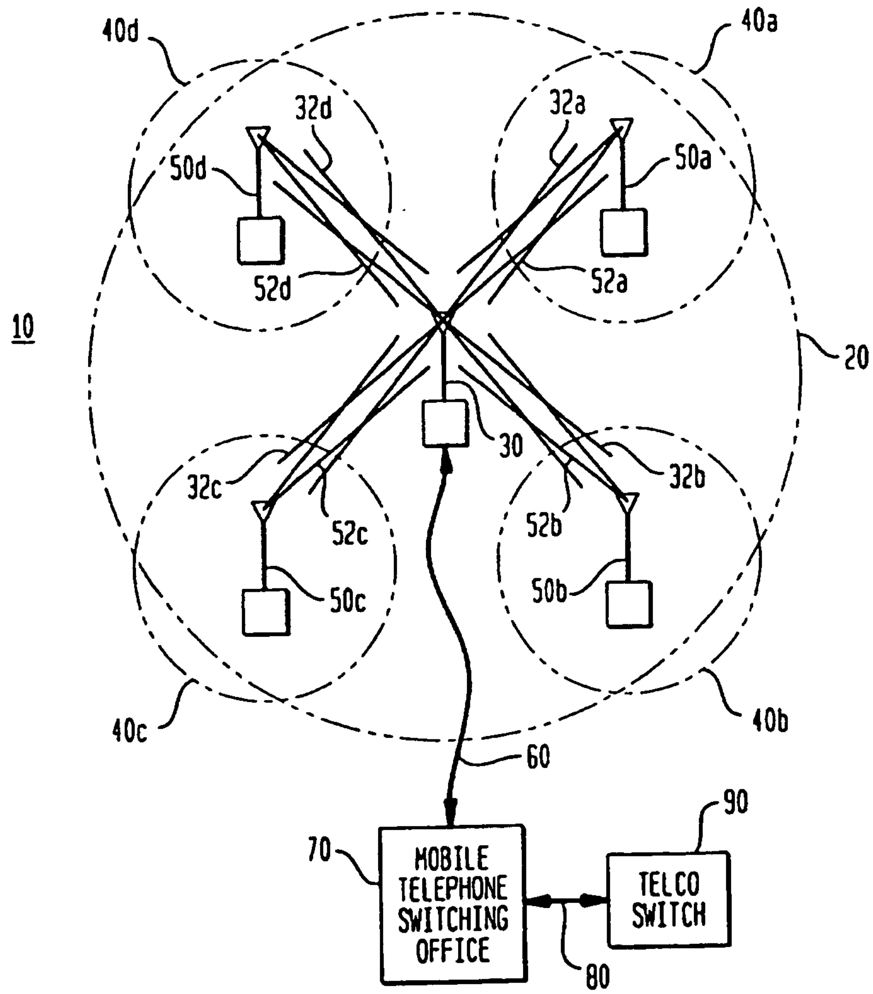
un filtrage au niveau de chacun desdits emplacements à distance afin de sélectionner la longueur d'onde qui est utilisée pour la partie de message pour une utilisation au niveau de cet emplacement à distance et afin de rejeter les longueurs d'onde qui sont utilisées pour les parties de message pour une utilisation au niveau d'autres desdits emplacements à distance.

31. Procédé selon la revendication 19, dans lequel une lumière d'une longueur d'onde différente est utilisée pour communiquer depuis chacun desdits emplacements à distance jusqu'audit emplacement central.

32. Appareil selon la revendication 1, dans lequel le récepteur (30) transfère, en utilisation, lesdits signaux de fréquence radio (52a-52d) sur ladite liaison de communication (60) jusqu'audit circuit de commande de communication sans fil (70) qui est un central de commutation de téléphone mobile.

33. Procédé selon la revendication 16, dans lequel ledit récepteur (30) transfère lesdits signaux de fréquence radio (52a-52d) sur ladite liaison de communication (60) jusqu'audit circuit de commande de communication sans fil (70) qui est un central de commutation de téléphone mobile.

FIG. 1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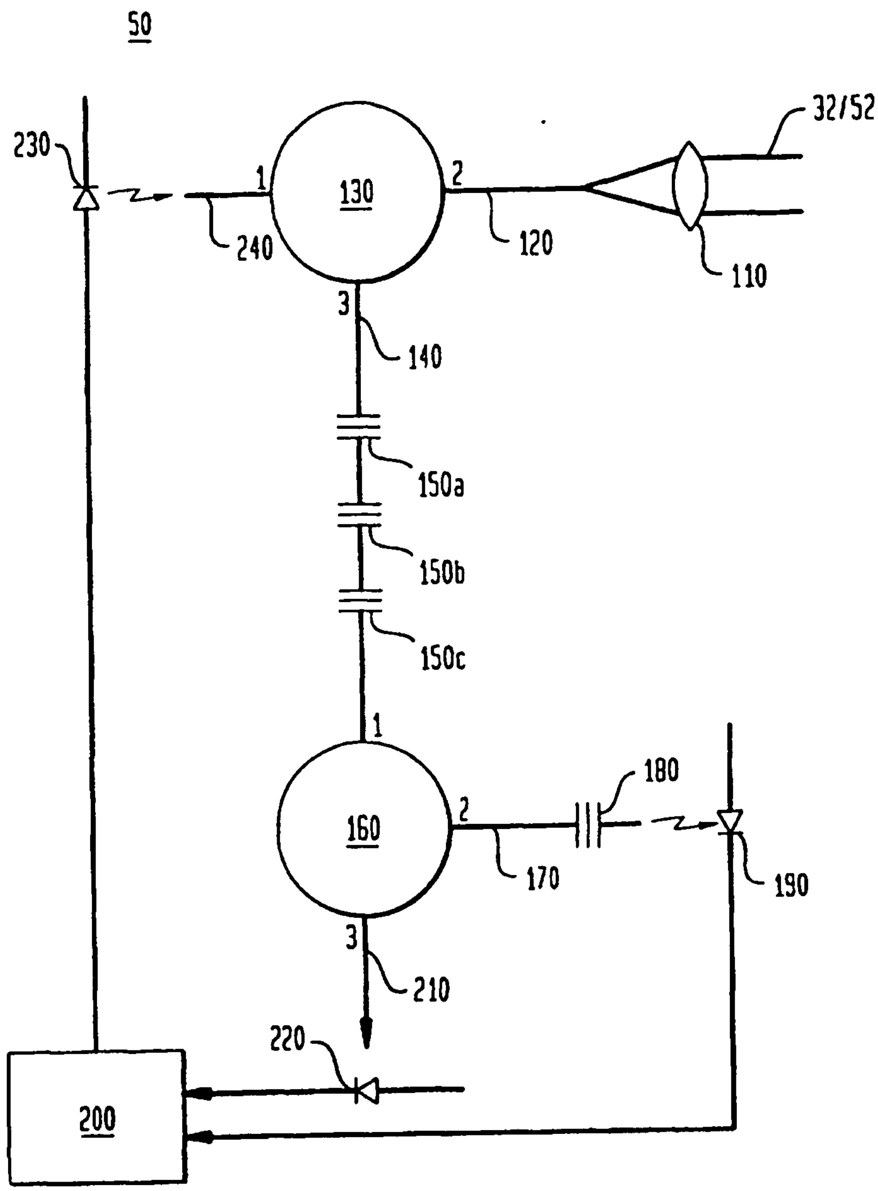
20
30
32a
32b
32c
32d
40a
40b
40c
40d
50a
50b
50c
50d
52a
52b
52c
52d
60
70
MOBILE TELEPHONE SWITCHING OFFICE
80
90
TELCO SWITCH

FIG. 2


50
230
1
130
2
32/52
240
120
110
3
140
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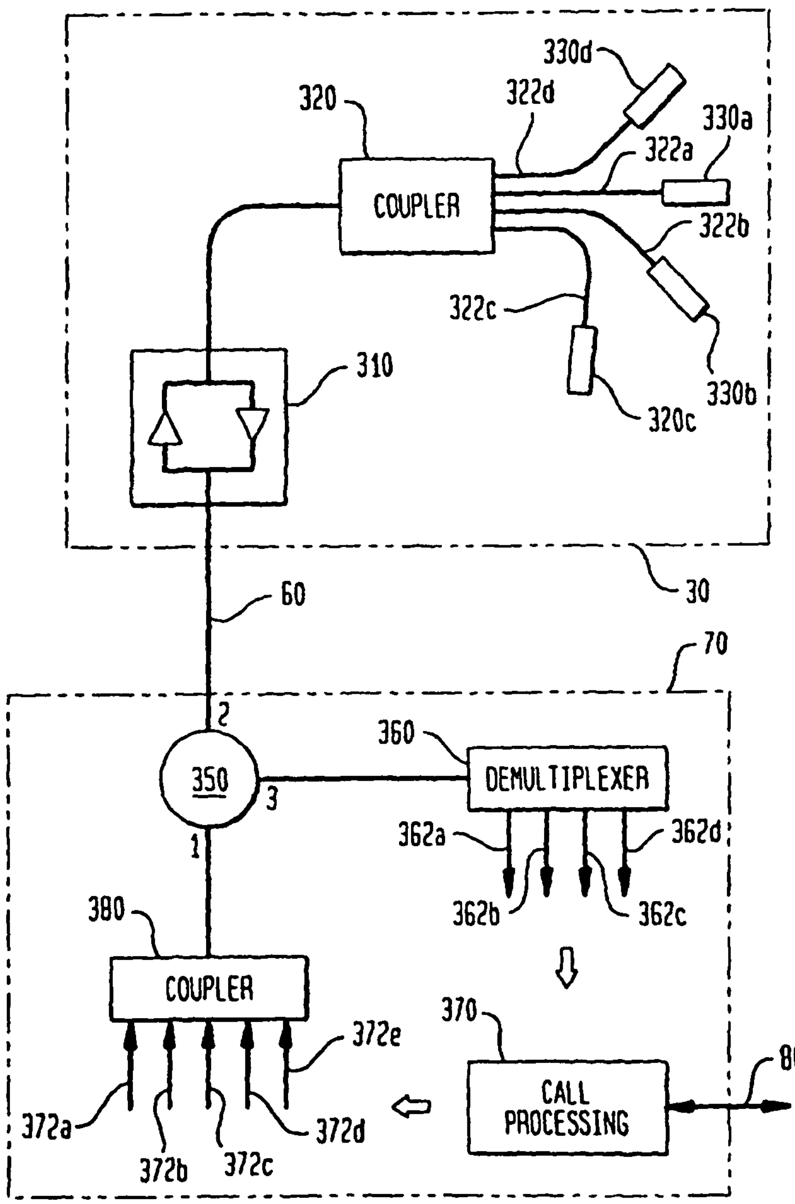
150b
150c
1
180
160
2
170
190
3
210
220
200

FIG. 3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DEMULTIPLEXER
3
1
362a
362d
380
362b
362c
COUPLER
370
372e
80
CALL
PROCESSING
372a
372d
372b
372c